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(54) **Ultraviolet-flame sensors**

(57) A UV-flame monitor which operates with ac voltage comprises a UV sensor 13 and a charge storage device 16 connected in parallel with the sensor and charged from an AC supply U_n at 11, 12 by diode 14. The charge storage device acts as a power supply device for the sensor which requires 200-250v to fire it and the charging current of the storage device is used as the output current of the monitor.

The firing readiness time of the monitor is increased over those operating on pure AC and an ionisation flame monitor can also be connected to the same terminals as the flame monitor. The voltage on the charge storage device may be increased by further capacitor / diode circuitry in the supply to the monitor.

Constructions for continuous operation of the burner and for intermittent operation of the burner are described. The firing readiness time of these constructions is 100% of the monitorable time, and use a shutter which alternately opens and closes between flame and UV sensor and circuitry which disconnects the UV cell and charge storage device when the shutter is closed.

Fig.2

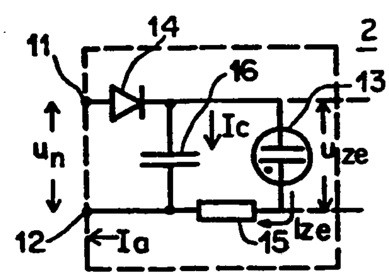

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Fig.1

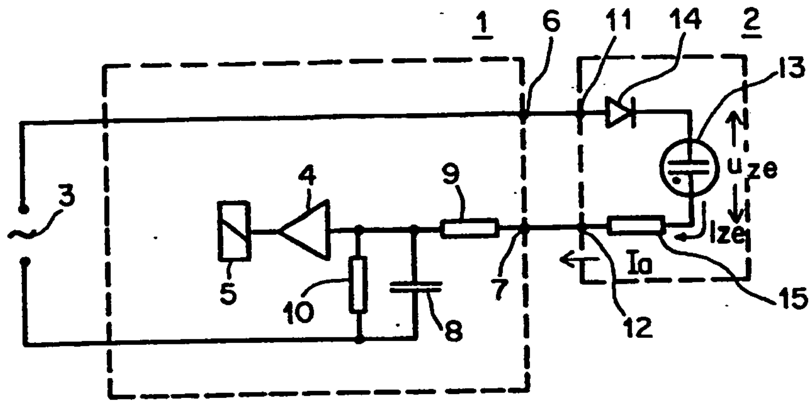

Fig.2

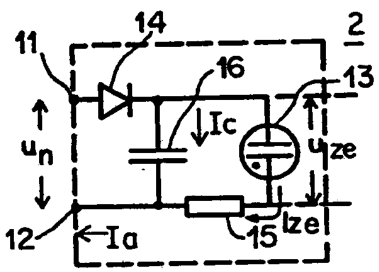

Fig. 3

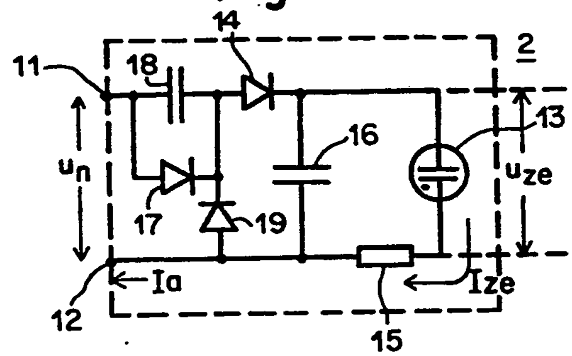

Fig.4

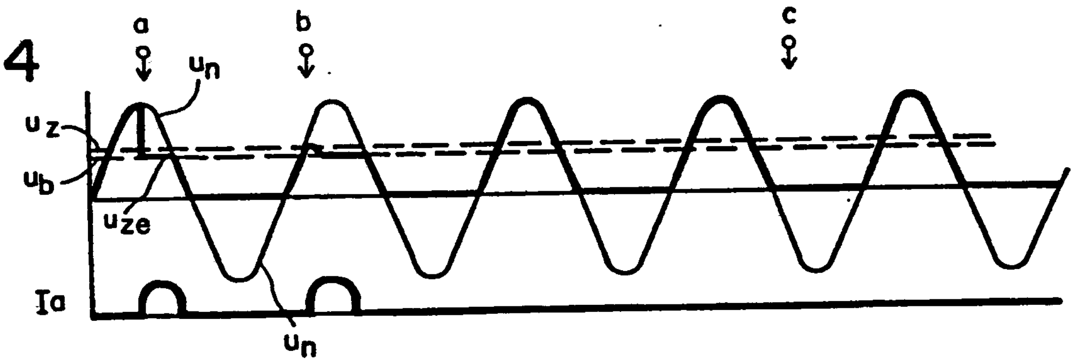

Fig5

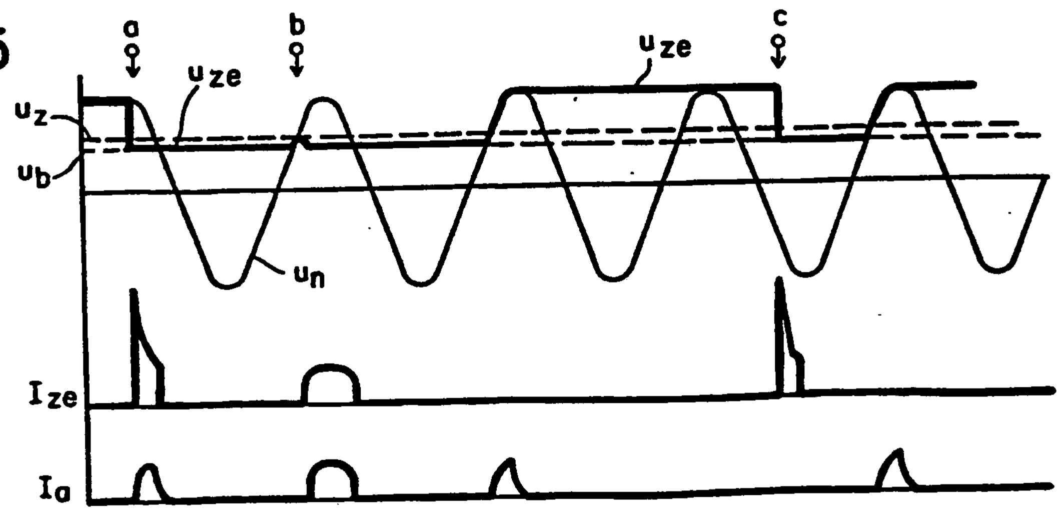

Fig.6

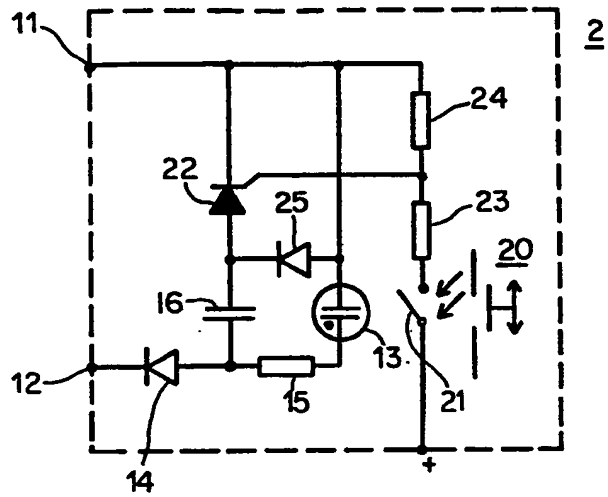
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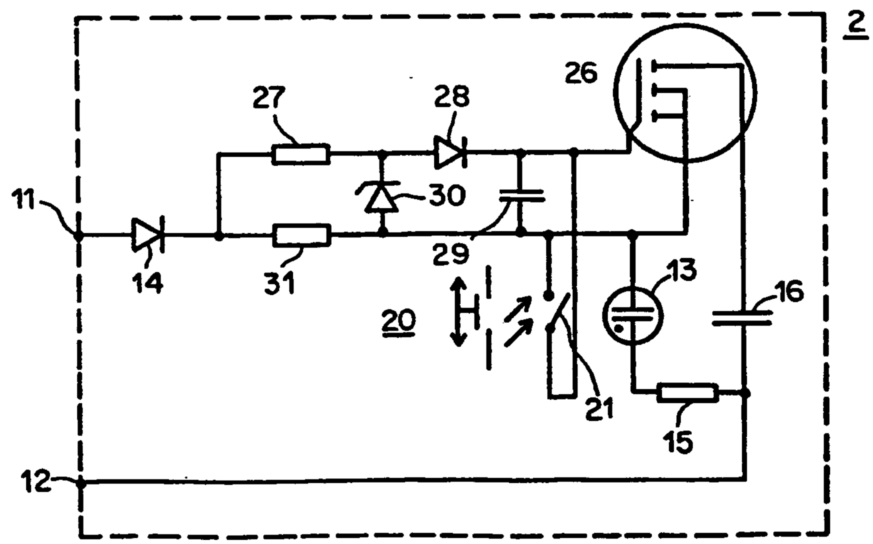
Fig.7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ULTRAVIOLET-FLAME SENSORS

This invention relates to ultraviolet (UV-) flame sensors for monitoring a flame in a burner installation.

Flame sensors are used in burner installations to detect whether the flame is burning properly therein. If the flame goes out during operation of the assembly, a series of safety measures must be immediately undertaken and in particular the supply of fuel must be shut off. Flame sensors on the one hand should not produce a signal indicating the presence of a flame in any situation if no such flame is present within a predetermined period, while on the other hand they should have a long readiness time for monitoring the flame in order to be able to signal "flame burning" at least once even in the event of substantial fluctuations in radiation within that predetermined time.

There are various kinds of flame sensor, for example ionisation flame sensors and various flame sensors which operate on a photoelectric basis. Of the latter, the UV-flame sensor which is responsive to ultraviolet radiation has proved successful for many purposes of use as it is not responsive to radiation in the visible or infrared range and can be put to use equally for monitoring oil and gas flames.

Flame sensors are operated in conjunction with flame monitors which process the signal of the flame sensor in such a way as to provide for actuation of what is referred to as a flame relay which, directly after the flame goes out, triggers the safety measures which are then required.

In various situations, for example in installations with a pilot burner flame which has to be monitored separately, it is necessary to use an UV-flame sensor and an ionisation flame sensor at the same time. As ionisation flame sensors have to be operated with ac voltage, it is advantageous for UV-flame sensors also to be operated with ac voltage so that only one kind of supply voltage has to be made available in the flame monitor.

The radiation-sensitive component of an UV-flame sensor, the UV-cell, has a firing voltage which is at 200 to 250 V, at best therefore at about 65% of the peak voltage of a 220 V ac network. Th refore the firing readiness time of an UV-cell is seriously

restricted when the arrangement is supplied with mains ac voltage. For that reason flame monitor circuits have been developed, in which the UV-cell of the flame sensor is operated with dc voltage (for example, as disclosed in German Patent Specification No. 2 308 524), but it is not possible for an ionisation flame sensor to be connected at the same time to such flame monitors.

UV-cells have a tendency with increasing age to suffer from spontaneous firing which is not caused by UV-radiation. Such firing phenomena produce the same signal as the presence of a flame. It is therefore repeatedly necessary to check whether such a defective condition is occurring, in relation to an UV-flame sensor. In that respect, in the case of burner installations in which the burner operates intermittently, the testing operation is effected during the breaks in burner operation and there is no need of a particular item of equipment for that purpose. In the case of burner installations which operate continuously, automatic testing devices must be provided, which, while the flame is burning, detect whether the UV-cell has reached the above-indicated dangerous ageing condition. It will be appreciated that the electronic circuit also has to be checked to ascertain whether it is not wrongly signalling a flame when there is not in fact any flame.

German Patent Specification No. 3 026 787 describes an UV-flame sensor for a burner installation which is operated with ac voltage and in which a diode is connected on the input side of the UV-cell. It is suitable for heating installations which operate continuously if it is provided with a shutter which opens and closes at a frequency which is markedly lower than the mains frequency. The flame sensor is then sensitive only while the shutter is in the open condition. In addition it is only sensitive during the period during which the half-cycle supplied by the diode is of a higher voltage than the firing voltage of the UV-cell, and its firing readiness time therefore attains only a comparatively short part of the overall operating time. The circuit does not involve a high level of expenditure on components, but its firing readiness time is short so that it does not always provide for trouble-free operation.

In accordance with the present invention there is provided an UV-flame sensor for monitoring a flame in a burner installation, which

s nsor is electrically connectable to a flame monitor for supply therefrom with an ac voltage, the sensor comprising an UV-cell which can be fired by UV-radiation from a flame, a charge storage means serving as a voltage source for the UV-cell, and a unidirectional charging means by which the charge storage means can be charged up to the peak value of the ac voltage, wherein the voltage of the charge storage means can be lowered to the burning voltage of the UV-cell by firing of the UV-cell, and the charging current of the charge storage means appears as the output current of the flame sensor.

Embodiments of the invention, to be described in greater detail hereinafter, provide UV-flame sensors which are operated with ac voltage but which nonetheless have the maximum firing readiness time.

The invention will now be described by way of example with reference to the accompanying drawings, throughout which like parts are referred to by like references, and in which:

Figure 1 is an UV-flame monitor with an UV-flame sensor of previously-proposed construction;

Figure 2 shows an UV-flame sensor according to an embodiment of the invention, for intermittent operation of the burner;

Figure 3 shows another UV-flame sensor, in which a storage capacitor is charged up to a voltage which is above the supply voltage of the flame sensor;

Figure 4 shows voltage and current diagrams relating to Figure 1;

Figure 5 shows voltage and current diagrams relating to Figure 2;

Figure 6 shows an UV-flame sensor with automatic testing device for a burner installation which operates in a constant mode; and

Figure 7 shows another such UV-flame sensor.

Figure 1 shows by way of example a flame monitor 1 which is connected to a flame sensor 2 and an ac voltage source 3 which is supplied from the mains. The flame monitor 1 has an amplifier 4 which is only sensitive to a dc voltage component and which acts on a flame relay 5 for controlling the supply of fuel to a burner. The flame monitor 1 is connected via terminals 6 and 7 by way of a cable to the output of the flame sensor 2. Provided between the terminal 7 and the input of the amplifier 4 is an electrical network which for example

may comprise a capacitor 8 and two resistors 9 and 10 and which has a connection to the ac voltage source 3. The capacitor 8 and the resistor 10 are connected in mutually parallel relationship between the feed line between the terminal 7 and the amplifier 4 and the feed line to the ac voltage source 3, while the resistor 9 is disposed upstream thereof between the input to the amplifier 4 and the terminal 7. If, by way of the cable connected to the terminal 7, the flame sensor 2 produces signals indicative of the presence of a flame in the burner installation, at a sufficient frequency, then the flame relay 5 causes the supply of fuel to be maintained.

The flame sensor 2 is connected to the cable to the flame monitor 1 by means of an input terminal 11 and an output terminal 12. The flame sensor 2 comprises, in series relationship between the input terminal 11 and the output terminal 12, a rectifier diode 14, an UV-cell 13 and a working resistor 15. This construction corresponds to the arrangement illustrated in the above-mentioned German Patent Specification No. 3 026 787 and may be considered as an earlier stage in the development of flame sensors according to the invention since, as will be shown hereinafter, its firing readiness time does not satisfy the requirements of the specified problem.

Figure 2 shows the simplest flame sensor embodying the invention for a burner installation which does not operate in a continuous mode. Disposed therein as a voltage source for the UV-cell 13 with working resistor 15 connected on the output side thereof is a storage capacitor 16 acting as a charge storage means, in conjunction with the rectifier diode 14 which is used as a unidirectional charging device and by means of which the storage capacitor 16 can be charged up to the positive peak value of the feed ac voltage source 3. The rectifier diode 14 is disposed between the input terminal 11 and the point joining the storage capacitor 16 and the UV-cell 13, that is to say in the charging circuit of the storage capacitor 16. The discharging circuit for the storage capacitor 16 comprises the UV-cell 13 and the working resistor 15.

After firing of the UV-cell 13, which is triggered by the UV-radiation of the flame (not shown in the drawings), the voltage of the storage capacitor 16 falls approximately to the burner voltage Ub. If the UV-cell 13 is fired during the positive half-cycle of the feed ac

voltage, then, after that fall in voltage, the cell current Ize of the UV-cell 13 flows as an output current Ia of the flame sensor 2 by way of the output terminal 12 to the flame monitor 1. As soon as the UV-cell 13 is not fired once in one of the following positive half-cycles, recharging of the storage capacitor 16 takes place, in which case the charging current Ic of the storage capacitor 16 appears as the output current Ia of the flame sensor 2. With the flame sensor 2 shown in Figure 2, testing for self-firing of the UV-cell 13 or for short-circuiting of the storage capacitor 16 must take place in the breaks in burner operation, and the flame sensor cannot therefore be used for installations which operate continuously.

Figure 3 shows a flame sensor 2 with a cascade circuit which charges up the storage capacitor 16 to a voltage which lies above the peak value of the supply voltage Un for the flame sensor 2. It also includes the UV-cell 13, the rectifier diode 14 and the working resistor 15, arranged in a similar manner to that shown in Figure 2. In addition, it includes a first auxiliary diode 17 which by-passes a cascade capacitor 18 in the feed line from the terminal 11 to the rectifier diode 14, and a second auxiliary diode 19 which is connected between the output terminal 12 and a point between the cascade capacitor 18 and the rectifier diode 14.

If it is assumed that initially the capacitors 16 and 18 do not carry any charge, then, after application of the ac voltage in the positive half-cycle, the storage capacitor 16 is charged up by way of the first auxiliary diode 17 and the rectifier diode 14. In the negative half-cycle the cascade capacitor 18 is charged up by way of the second auxiliary diode 19 and is discharged to the storage capacitor 16 in the following positive half-cycle by way of the rectifier diode 14. The voltage at the storage capacitor 16 can thus rise to double the peak value as long as the UV-cell 13 does not fire. With the first auxiliary diode 17 in parallel with the cascade capacitor 18, the direct current component required for the evaluation operation, in the output current Ia of the flame sensor 2, is reached when the UV-cell 13 fires. This circuit increases the difference, which is otherwise too small in the event of mains undervoltage, between the voltage at the storage capacitor 16 and the firing voltage Uz (Figures 4 and 5) of th UV-cell shown in Figure 2, and thus

improves the operational reliability of the installation. This construction can also be used only for burner installations which do not operate continuously.

The mode of operation of the flame sensor shown in Figure 1 is illustrated in Figure 4 while that of the flame sensor shown in Figure 2 is illustrated in Figure 5. In this connection, the diagrams plot the configuration of the voltage Uze, present at the electrodes of the UV-cell 13, in the upper row, an output current Ia which is fed to the flame monitor, in the lower row, while in Figure 5, a current Ize flowing in the UV-cell circuit is plotted in the middle row, in each case in dependence on time. The marks identified by a, b and c above the upper row indicate as an "occurrence" the impingement of an UV-photon on the cathode of the UV-cell 13. In addition, the upper row indicates in each case the firing voltage Uz and the burning voltage Ub of the UV-cell 13 and the supply voltage Un.

The supply voltage shown in Figure 4 which relates to the arrangement of Figure 1 is also applied during its positive half-cycle to the UV-cell 13 as long as no UV-radiation is acting thereon and it is therefore not fired. When UV-radiation is present, that is to say a flame is burning, and the UV-cell 13 is in the condition of firing readiness, that is to say the instantaneous value of the cell voltage Uze at the UV-cell 13 is greater than its firing voltage Uz, the UV-cell 13 can fire and the cell voltage Uze goes back to the value of the burning voltage Ub and remains at that value until the supply voltage Un falls below that value and the UV-cell is extinguished. In that case an output current Ia flows to the flame monitor 1, which corresponds to the respective difference between the instantaneous value of the supply voltage Un and the burning voltage Ub at the UV-cell 13. If an UV-photon is incident at a time indicated by the mark c, in which the UV-cell 13 is not in a condition of firing readiness, that occurrence is not signalled. That is the situation over the duration of the negative half-cycle of the supply voltage Un and over the period of time for which the instantaneous value of the cell voltage Uze is lower than the firing voltage Uz, that is to say for more than half the total time. The firing readiness time f the UV-flame sensor 2 shown in Figure 1 thus does not comply with the requirements set by the specified problem.

In the case of the flame monitor shown in Figure 2, the performance of which is illustrated in Figure 5, the cell voltage Uze is held by the storage capacitor 16 at the peak value of the positive half-cycle of the supply voltage Un, when the flame is not burning. It drops to the value of the burning voltage Ub after firing of the UV-cell 13, which is caused by the burning flame, and in that case there flows a cell current Ize which is registered as the output current Ia of the flame monitor 1 (Figure 1). The voltage at the storage capacitor 16 remains at the value of the burning voltage Ub when the cell is always fired during the positive half-cycles. If however no UV-radiation occurs in one of the next positive half-cycles, and therefore firing of the UV-cell 13 does not take place, the storage capacitor 16 is re-charged by that half-cycle and retains its voltage until the cell is fired again. The charging current Ic which occurs in that case is interpreted by the amplifier 4 (see Figure 1) as the output current Ia of the flame sensor 2, as though an occurrence had taken place in that positive half-cycle of the supply voltage Un. If the occurrences initially take place only in the positive half-cycles, they are signalled individually, but in the next following occurrence-less positive half-cycle, recharging of the storage capacitor 16 is in principle also signalled as an occurrence. As that occurrence takes place within a very short time, namely within a period after possible extinguishing of the flame, that signalling is of no importance.

The fact that the peak value of the supply voltage Un is stored in the storage capacitor 16 therefore provides for an increase in the firing readiness time of the flame sensor 2. It is not just the occurrences which are identified by the marks a and b in the positive half-cycle of the supply voltage Un that are signalled to the flame monitor 1, as in the case of the flame sensor 2 shown in Figure 1, but also the occurrence which does not coincide with a positive half-cycle and which is identified by the mark c, if only the storage capacitor 16 is then charged up by way of the firing voltage Uz. Signalling of that occurrence then takes place at the time at which the occurrence-less positive half-cycle following the occurrence charges up the storage capacitor 16 again.

If the occurrences take place so frequently that firing of the

UV-cell 13 takes place in every positive half-cycle, then in regard to the output current Ia there is practically no difference b tween a flame sensor 2 as shown in Figure 1 and a flame sensor as shown in Figure 2. Both flame sensors 2 are then in a saturation condition. The advantages of the flame sensor 2 shown in Figure 2 are encountered all the more in direct proportion to the increasing rarity with which the occurrences take place in the firing readiness time of the flame sensor 2 in Figure 1, instead of which however they occur in the time for which the supply voltage Un is lower than the firing voltage Uz. A theoretical firing readiness time of 100% is achieved with the arrangement shown in Figure 2.

The flame sensor 2 shown in Figure 6 is suitable for burner installations which operate in a continuous mode. The flame sensor has an UV-cell 13, a rectifier diode 14, a working resistor 15 and a storage capacitor 16 which are arranged in a similar manner to that shown in Figure 2. In addition, disposed in a beam path (not shown) between the flame and the UV-cell 13 is a shutter 20 which alternately opens and closes the beam path. The frequency at which the shutter 20 operates is substantially lower than the frequency of the supply voltage Un. A thyristor 22 acts as a switching means between the storage capacitor 16 serving as the charge storage means, and the UV-cell 13; the thyristor 22 is switched on and off by a switch 21 which receives a positive voltage at one side and which is controlled synchronously by the shutter 20, by way of the voltage divider chain formed by a series resistor 23 and a gate shut-off resistor 24. Thus, with the beam path closed, the storage capacitor 16 is separated from the UV-cell 13 so that during that period of time the UV-cell 13 is only subjected to the influence of the half-cycle voltage supplied by way of the rectifier diode 14. A first diode 25 connects the storage capacitor 16 to the input terminal 11 of the flame sensor 2.

The circuit operates in the following manner. The storage capacitor 16 is charged up by way of the rectifier diode 14 and the first diode 25. If the shutter 20 is open, the switch 21 conducts and therefore also the thyristor 22, and the flame sensor 2 operates over at least a number of periods of the supply voltage Un, as described in relation to Figures 2 and 5. If the shutter 20 is closed, the UV-cell 13 does not receive any radiation and theref re no output signal can

be delivered to the flame monitor 1. As in that case the thyristor 22 is also in a non-conducting condition, the storage capacitor 16 no longer acts as a voltage source for the UV-cell 13 since the first diode 25 also prevents discharging of the storage capacitor 16. The UV-cell 13 is then ready for firing only in the substantially shorter times during which the supply voltage Un is above the firing voltage Uz, as shown in Figure 4.

Now, the following defects may occur, which in that situation can trigger off firing of the UV-cell 13 although the flame sensor 2 is separated from the flame by the shutter 20:

- the UV-cell 13 receives UV-photons sporadically, due to leakage, because the shutter 20 is not absolutely tight; or
- the UV-cell 13 has aged and fires spontaneously by virtue of the applied voltage or has a short-circuit.

If the first defect occurs, that is signalled to the flame monitor 1 only to a reduced degree, by virtue of the short firing readiness time, with the storage capacitor 16 cut out. The flame monitor suppresses such signallings if they do not occur too frequently, and considers the UV-cell 13 and the radiation-tightness of the shutter 20 as defect-free until the frequency of the firing phenomena, with the shutter 20 closed, reaches the degree which is required with the shutter open for the "flame burning" signal. It is only then that further operation of the flame monitor 1 is prevented. That applies for example in regard to the second defect referred to above, and in regard to short-circuiting of the storage capacitor 16. All other possible defects only reduce the firing readiness time of the flame sensor 2.

Figure 7 shows a corresponding flame sensor 2 in a modified circuit. In that flame sensor, the storage capacitor 16 is cut out by a MOS-FET switch 26 whose control voltage is formed directly from the voltage drop of the second working resistor 31 which is disposed in the UV-cell circuit. The control voltage is branched off on the output side of the rectifier diode 14 and passed by way of a resistor 27 and a second diode 28 to a second storage capacitor 29 which is disposed between the line for th control voltage and the UV-cell circuit, and applied to the gate of the MOS-FET switch 26. The second diode 28 prevents unintended discharging of the second storage

capacitor 29, through the resistors 27 and 31. The gate is pr tected from overvoltages by means of a Zener diode 30 which is connected in parallel with the second storage capacitor 29. The arrangement is controlled by a switch 21 which is connected between the source and the gate of the MOS-FET switch 26. The switch 26 may be either an electromechanical component or an electronic component, for example an optocoupler. The source of the MOS-FET switch 26 is connected to a terminal of the UV-cell 13 while the drain is connected to the storage capacitor 16.

The MOS-FET switch 26 is closed when the shutter 20 is closed and the switch 21 is conducting. That then gives rise to the same conditions as in the case described hereinbefore in relation to Figure 6, when the switch 21 is open therein.

It is also possible to provide flame sensors in which a movable shutter 20 and a voltage multiplier circuit, as was described with reference to Figure 3, are used together.

The flame sensor 2 as described above with reference to the various embodiments is operated with ac voltage and has a firing readiness time of 100% of the time for which it is not masked relative to the flame by the shutter 20 when such is provided. It can be tested for defects which feign the presence of a flame, during breaks in burner operation or, in the case of the constructions which are suitable for burner installations for continuous operation, by virtue of the movement of the shutter 20. However, in the case of the construction designed for continuous operation, any deviation from the reference output signal, including defects in the shutter movement, results in a "no flame present" signal at the output of the flame monitor, which results in the supply of fuel being cut off. The flame sensors are therefore fail-safe.

CLAIMS

1. An UV-flame sensor for monitoring a flame in a burner installation, which sensor is electrically connectable to a flame monitor for supply therefrom with an ac voltage, the sensor comprising an UV-cell which can be fired by UV-radiation from a flame, a charge storage means serving as a voltage source for the UV-cell, and a unidirectional charging means by which the charge storage means can be charged up to the peak value of the ac voltage, wherein the voltage of the charge storage means can be lowered to the burning voltage of the UV-cell by firing of the UV-cell, and the charging current of the charge storage means appears as the output current of the flame sensor.

2. An UV-flame sensor according to claim 1, wherein the charge storage means comprises a storage capacitor which is connected in parallel with the UV-cell and which includes as the unidirectional charging means at least one rectifier diode which is disposed in an electrical supply line to the junction between the storage capacitor and the UV-cell.

3. An UV-flame sensor according to claim 2, wherein the storage capacitor can be charged up by the charging means to a voltage which is above the supply voltage of the flame sensor.

4. An UV-flame sensor according to claim 3, comprising a first auxiliary diode which by-passes a cascade capacitor connected between an input terminal and the rectifier diode, and a second auxiliary diode which is disposed between an output terminal and a point between the cascade capacitor and the rectifier diode.

5. An UV-flame sensor according to any one of the preceding claims, comprising a shutter which is disposed in a beam path between the flame and the UV-cell and which alternately opens and closes the beam path, and a switching means provided between the charge storage means and the UV-cell by which the charge storage means and the UV-cell can be disconnected when the shutter is closed.

6. An UV-flame sensor according to claim 5, wherein the switching means comprises substantially a switch and a thyristor.

7. An UV-flame sensor according to claim 5, wherein the switching means comprises substantially a switch and a MOS-FET switch.

8. An UV-flame sensor for monitoring a flame in a burner installation, the sensor being substantially as hereinbefore described with reference to Figure 2, Figure 3, Figure 6 or Figure 7 of the accompanying drawings.

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ABSTRACT:

CHG DATE=19940730 STATUS=O> A UV-flame monitor which operates with ac
voltage comprises a UV sensor 13 and a charge storage device 16 connected in parallel with the sensor and charged from an AC supply Un at 11, 12 by diode 14. The charge storage device acts as a power supply device for the sensor which requires 200-250v to fire it and the charging current of the storage device is used as the output current of the monitor. The firing readiness time

of the monitor is increased over those operating on pure AC and an ionisation flame monitor can also be connected to the same terminals as the flame monitor.

The voltage on the charge storage device may be increased by further capacitor / diode circuitry in the supply to the monitor. Constructions for continuous operation of the burner and for intermittent operation of the burner are described. The firing readiness time of these constructions is 100% of the monitorable time, and use a shutter which alternately opens and closes between flame and UV sensor and circuitry which disconnects the UV cell and charge storage device when the shutter is closed. <IMAGE>